SEVERAL TECHNIQUES FOR ONE–DIMENSIONAL STRAIN SHOCK CONSOLIDATION OF MULTIPLE CAVITIES:

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The advantages of one–dimensional shock consolidation include simple characterization of shock conditions, uniform shock conditions across the majority of the material, and the retention of the original shape in two of three dimensions. Flyer plate experiments which use this geometry typically form only one thin compact. When investigating a system, it is highly cost effective to make multiple specimens from each shot. This also insures that each specimen receives the same flyer plate velocity. This is typically done by striking a hard steel fixture with several embedded cavities, and leads to highly two and three dimensional shock conditions which can hamper characterization and recovery. We have explored three methods which retain the one–dimensional nature of the shock wave, while allowing multiple samples to be consolidated.

The first technique uses a porous sintered metal cylinder as a shock fixture. The sintered material is chosen to match as closely as possible the solid density and compressibility of the powder to be investigated. The porosity is chosen to match that of the powder to be shock consolidated. A coating of release agent is applied to the inner walls of the porous material. The powder is then loaded and shock consolidated. In our experiments, elemental nickel powders of different shapes were shock consolidated. A porous bronze filter material was chosen as a shock impedance match. The bronze was machined into a cylinder, and four holes were drilled to form cavities. Ni powders were then pressed into the cavities, and shock consolidated. The same type of bronze was used for the shock consolidation of a maraging steel. When the impedance match is correct, the shock consolidation results in a single flat compact with samples embedded in it.

The second method is available without a compatible porous material. A cylindrical target cavity is separated into multiple regions by thin sheet metal dividers. The dividers must be much thinner than the cavity size, and preferably of the same thickness as the powder diameter, to retain a one dimensional condition in most of the compact. We shock consolidated maraging steel powders of different size distribution in a divided cavity. Three powder size mixes of M350 maraging steel were prepared and loaded into a single cylindrical cavity divided into three sectors by a 125μm thick 304 SS divider, and impacted with a 303 SS flyer plate at 1.28 km/s. Three well bonded sectors were easily separated from the divider (which had been coated with a colloidal carbon release agent.)

The third method is perhaps the most interesting from a technological standpoint. A powder media of near impedance match to the material under study is selected which does not bond to itself under the shock conditions to be used. Pressed greens of the material to be consolidated are then embedded in this pressure–transmitting media and then processed with an incident plane shock wave. In our experiment, a discontinuosly reinforced metal matrix composite (MMC) was shock consolidated to near net shape by this method. Ti powder was mixed with SiC powder, pressed into a green with corners and radii, and embedded in fine zirconia powder. A one km/s shock wave fully consolidated the MMC without bonding the zirconia. The compact was recovered with well defined corners and flat surfaces, as desired. This technique is amenable to scale–up.